

**M.TECH/ECE/2<sup>ND</sup> SEM/ECEN 5201/2015  
2015**

**Photonics and Optical Communication  
(ECEN 5201)**

**Time Allotted : 3 hrs**

**Full Marks : 70**

***Figures out of the right margin indicate full marks.***

***Candidates are required to answer Group A and  
any 5 (five) from Group B to E, taking at least one from each group.***

***Candidates are required to give answer in their own words as far as  
practicable.***

**Group - A**

**(Multiple Choice Type Questions)**

1. Choose the correct alternative for the following: **10 x 1=10**
- (i) The most important semiconductor laser material for operation at 1550 nanometers is
- (a) Germanium(Ge)  
(b) Gallium Arsenide (GaAs)  
(c) Indium Gallium Arsenide Phosphide (InGaAsP)  
(d) Indium Phosphide (InP).
- (ii) Which of the following wavelengths (in units of micrometers) is suitable for pumping an EDFA ?
- (a) 0.82                      (b) 0.98                      (c) 1.30                      (d) 1.55.
- (iii) Which of the following optoelectronic detectors are sensitive for detection of very weak signals ?
- (a) p-n photodiode                      (b) p-i-n photodiode  
(c) Avalanche photodiode                      (d) Photovoltaic detector.
- (iv) If in a step index fiber, the core refractive index is 1.50 and the cladding refractive index is 1.47, the numerical aperture will be
- (a) 0.244                      (b) 0.298                      (c) 0.344                      (d) 0.98.
- (v) If Germanium has a bandgap of 0.67 eV, the maximum wavelength (in unit of nanometers) that can be absorbed by a germanium photodetector is
- (a) 6080                      (b) 4360                      (c) 3700                      (d) 1850.
- (vi) For heterodyne detection of an optical signal in a coherent lightwave system, the fluctuations in the phases of the optical source and local oscillator are controlled by
- (a) use of single frequency lasers  
(b) use of optical PLL  
(c) by increasing the local oscillator power  
(d) by using Lithium Niobate (Li Nb O<sub>3</sub>) modulators.

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- (vii) In a coherent lightwave communication system with FSK modulation of signals the total bandwidth of the FSK signal (with  $\Delta f$ , the frequency deviation and B, the bit rate) is given by
- (a)  $\Delta f + B$  (b)  $2 \Delta f + B$   
(c)  $2 \Delta f + 2B$  (d)  $\Delta f + 2B$ .
- (viii) For a coherent lightwave communication system asynchronous demodulation cannot be used for the following formats:
- (a) DPSK (b) PSK (c) ASK (d) FSK.
- (ix) FSK signals can be generated by using direct modulation capability of semiconductor lasers. A change in the operating current of the laser (of about 1 mA) produces an FSK signal with frequency shift of the order of
- (a) 1 MHz (b) 10 MHz (c) 100 MHz (d) 1 GHz.
- (x) The basic transmission bit rate in SDH (Synchronous Digital Hierarchy) is equivalent to
- (a) STS-1 (b) STS-3 (c) STS- 12 (d) STS- 24

### Group - B

- 2.(a) Draw the block schematic of a semiconductor heterojunction LED and explain its principles of operation. What do you understand by the following terms: "Optical confinement " and " Carrier Confinement" ?
- (b) For a GaAs semiconductor laser, the end reflectivities are  $R = 0.32$ . If the effective absorption co-efficient of the material is  $\alpha = 10$  per cm , find from first principles, the value of the threshold gain.
- 6+6=12**
- 3.(a) Draw a suitable cross-sectional structure of p-i-n photodetector and explain its principles of operation. Explain what is meant by "Responsivity " of a detector.
- (b) What do you understand by the term EDFA? Draw the energy band diagram of  $\text{Er}^{3+}$  ions in silica host lattice and hence explain the operation of an EDFA.
- 6+6 = 12**

### Group - C

- 4.(a) Draw the block schematic diagram of an Analog optical link. Explain the major parameters that contribute to noise in the system.
- (b) Show, with the help of a neat diagram, the biasing conditions of a laser diode and its response to analog signal modulation.
- 6+6=12**
- 5.(a) What is meant by a " Dispersion limited optical system" ? Show that for such a system, the bit rate B and maximum length  $L_{\text{max}}$  is given by the formula

$$4 .D. \Delta\lambda. B. L_{\max} \leq 1$$

where D is the dispersion co-efficient (in units of ps / km.nm ) and  $\Delta\lambda$  is the emission linewidth of the optical source.

- (b) An optical fiber uses a single mode fiber at  $\lambda = 1550$  nm with  $D = 16$  ps / km.nm and  $\Delta\lambda = 1$  nm . Find the value of the maximum length  $L_{\max}$  for a bit rate  $B = 2.5$  Gbps. Explain the statement that optical fibers are loss limited rather than dispersion limited.

**6+6=12**

**Group - D**

- 6.(a) What do you understand by the term “Coherent Lightwave system“ ? Why is it so called? Derive an expression for the current in the receiver in terms of the optical signal power, the local oscillator power , the phases of the optical signal and the local oscillator and the receiver sensitivity for a heterodyne receiver system.

- (b) Draw a neat diagram showing the modulation formats for ASK, PSK and FSK for a bit pattern 10011101.

**6+6=12**

- 7.(a) What is Wavelength Division Multiplexing ? Discuss the implementation of a typical WDM network containing various types of Optical Amplifiers.

- (b) What is a “ Bragg Grating “ ? Discuss the fabrication of a Bragg Grating in a fiber core by means of two intersecting ultraviolet beams.

**6+6=12**

**Group - E**

- 8.(a) Draw and explain the basic formats for an STS-3 SONET (Synchronous Optical Network) frame and STM-64 SDH (Synchronous Digital Hierarchy) frame.

- (b) Discuss the architecture of a four-fiber Bidirectional Line Switched Ring (BLSR) with suitable diagrams. Mention its important features.

**6+6=12**

- 9.(a) What is Dense WDM (DWDM ) ? Write a short note on dense WDM deployment of a number of different wavelengths in an OC-192 Trunk RING?

- (b) Draw suitable diagrams showing the architecture of a single hop broadcast - and - select network and discuss its important features. What is meant by Protocol transparent network ?

**6+6=12**